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CLINICAL REPORTS

A prospective study to evaluate the treatment effect of pulsed dye laser on thyroidectomy hypertrophic scars using 3D imaging analysis

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Abstract

Objectives: The pulsed dye laser (PDL) is an effective modality for preventing and improving hypertrophic scars (HSs). However, the heterogeneity of the parameter settings of the laser and subjective scar assessment methods used in most studies resulting in uncertainty with treatment plans. Therefore, we investigated the treatment effect of the PDL (V-beam; Candela Laser Corporation) on HSs in post-thyroidectomy patients using three-dimensional imaging analysis and intended to provide a systemic and optimal treatment protocol.

Methods: Nineteen patients with HS after thyroidectomy underwent eight treatment sessions with the 595 nm PDL (with the dose gradually increased by 0.5 J/cm^2) at 4- to 6-week intervals. Patients with an elevated lesion also received intralesional corticosteroid (ICS) treatment. After every two treatment sessions, we assessed the patients' HS using the Vancouver Scar Scale (VSS), a patient satisfaction questionnaire, and with a three-dimensional (3D) skin imaging device (Antera 3D™; Miravex Limited).

Results: In repeated-measures analysis of variance, the mean VSS and patient satisfaction significantly improved ($p < 0.001$), with significant differences in these values observed until the sixth and eighth treatment sessions, respectively. In the quantitative analysis using Antera 3D™, the mean height, pigmentation, and vascularity scores were observed to be significantly improved ($p < 0.001$). Significant differences in these values were observed until the fourth, second, and eighth treatment sessions, respectively. Subgroup analysis according to ICS treatment showed no significant differences in scar characteristics between those with and without ICS treatment.

Conclusions: In this study, we found that the PDL was effective in reducing scar height, vascularity, and pigmentation in patients with thyroidectomy HS using 3D imaging analysis. Furthermore, we have suggested a cost-effective treatment plan with the 595 nm PDL.

KEYWORDS

hypertrophic scar, intralesional corticosteroid treatment, pulsed dye laser, thyroid cancer, thyroidectomy

INTRODUCTION

Thyroid cancer is currently the most common endocrine malignancy and one of the most rapidly increasing malignant tumor types worldwide.[1,2] Although alternative surgical methods such as transoral endoscopic or robotic thyroidectomy have been attempted to avoid visible scars on the neck,[3,4] traditional open thyroidectomy approaches through transverse incisions in the neck are still the most commonly used techniques for thyroid cancer surgery. Subsequent visible hypertrophic scars (HSs) on the neck are the most common cutaneous side effects after thyroid cancer surgery,[5] and these cause significant cosmetic

problems that result in functional impairment and psychosocial burdens.[6,7]

Various modalities have been used to improve the appearance of postsurgical HSs, such as topical agents, intralesional corticosteroid (ICS) injections, laser procedures, compression therapy using elastic bandages, cryosurgery, and surgical scar revision.[8–10] All these treatment methods have their own limitations and their efficacy is still not established. The 595 nm pulsed dye laser (PDL), an effective modality for reducing scar erythema, volume, and pruritus, is the most preferred and well-tolerated treatment option because of its convenience and safety.[11–13] However, it may be inconsistently used due to its high cost, which means its complete treatment effect may not have been observed. Therefore, for successful treatment outcomes, it is important for clinicians to not only discuss with patients their needs and concerns but also to notify them of the expected outcomes based on the objective scar assessments. However, the factors contributing to the uncertainty of the treatment plan are the heterogenous parameter settings of laser treatment and the subjective scar assessment methods used in most studies.[14] Furthermore, most PDL studies are focused toward the treatment of hypertrophic burn scars or random surgical wounds rather than thyroidectomy HSs.[12,15,16]

In this prospective study, we aimed to objectively measured the treatment effect of the 595 nm PDL on thyroidectomy HSs using three-dimensional imaging analysis. Accordingly, we provided a systemic treatment protocol for the use of PDL in the treatment of thyroidectomy HSs and proposed a cost-effective treatment plan.

METHODS AND MATERIALS

Study participants

A total of 19 adults (>20 years of age) patients with HSs who had undergone open thyroidectomy at the Department of Dermatology of the Ajou University Hospital participated in the study. The diagnosis of HS was clinically confirmed by a dermatologist. We included only linear HSs that were limited to the anterior neck region after total thyroidectomy by the same surgeon; this was done to minimize the potential bias on the treatment results caused by injury type, wound size and depth, anatomic region, and mechanical tension. We excluded patients who were younger than 19 years at the initial clinic visit, had medical conditions other than thyroid disease, had a history of keloid scars or delayed wound healing, and had any previous internal or surgical thyroid scar management except for silicone gel sheets. This study design was reviewed and approved by the institutional review board of Ajou University Hospital (AJIRB-MED-MDB-22-006).

Treatment protocol

Several weeks after open thyroidectomy, each patient received eight sessions of the PDL (V-beam; Candela Laser Corporation) treatment at 4- to 6-week intervals. The initial parameters were as follows: Fluence, 7.0 J/cm^2; spot size, 7 mm; pulse duration, 6 milliseconds. During the second session, we changed the pulse duration to 3 milliseconds, and gradually increased the fluence dose by 0.25 J/cm^2. Each PDL session was applied with two pass and used with an overlap of 30% of the area in adjacent spots. The cooling parameters were used with dynamic cooling spray/delay time of 30/20 milliseconds. Furthermore, in case pliability score of Vancouver Scar Scales (VSSs) was more than 1, ICS injections using triamcinolone acetate (50 mg/5 ml) was also given following PDL treatments.

Scar assessments

A subjective scar assessment was performed before treatment initiation and after every two treatment sessions. During each assessment, two dermatologists subjectively assessed the effectiveness of the treatments using the VSS[17,18] and a patient satisfaction questionnaire. The VSS assesses the patient's scar vascularity, height, pliability, and pigmentation, with a maximum total score of 13. The patient satisfaction scores were graded from 0 to 4 (0, 0%; 1, 1%–24%; 2, 25%–49%; 3, 50%–74%; and 4, 75%–100%). We also objectively assessed the patients' scar height, pigmentation, and vascularity using a three-dimensional skin imaging device (Antera 3D™; Miravex Limited) that quantified these characteristics for an accurate comparison of the before and after images with little error. This device has been widely used in studies of various skin disorders.[19–22]

Statistical analysis

The patients' scar characteristics and VSS scores and patient satisfaction questionnaires were compared using a one-way repeated-measures analysis of variance (ANOVA) to evaluate statistical significance. In addition, pairwise comparisons using Bonferroni post-hoc tests were performed to determine any significant difference between the pairs of conditions. Statistical significance was considered for a two-tailed $p < 0.05$ and the effect size of different variables in ANOVA model was measured using partial eta squared. The statistical analyses were performed using SPSS Statistics for Windows (version 20.0; SPSS Inc.).

RESULTS

Demographic and clinical characteristics of the study participants

All the study participants were female patients with a Fitzpatrick skin type III (26.3%) or IV (73.7%); the median age of the patients was 39 years (interquartile range [IQR] 30–43 years). All patients, except one, had papillary thyroid cancer; the median disease duration of their HSs was 80 days (IQR 22–177 days). The median VSS score measured at baseline was 9 (IQR 8–10). All the patients had previously received treatment with silicone gel sheets only, whereby the patients applied silicon sheets to their lesions. No history of any other scar treatment intervention was noted. The demographic and clinical characteristics are shown in Table 1.

Treatment outcomes

The changes in the mean patient satisfaction and VSS scores over the eight treatment sessions are illustrated in Figure 1. The results of the ANOVA of one-way repeated measures indicated a significant increase in mean patient satisfaction score ($p < 0.001$; effect size 0.876) and significant decrease of mean VSS scores from 8.84 to 3.63 ($p < 0.001$; effect size 0.743). We also performed pairwise comparisons to determine the statistical significance between the pairs of conditions. Although mean patient satisfaction scores significantly increased at all time intervals, no significant difference was observed in the mean VSS scores between the sixth and eighth PDL sessions (mean difference 0.579).

Figure 2 shows the results of the quantitative analysis using Antera 3D™. The mean scores of the patients' scar height (effect size 0.431), pigmentation (effect size 0.402), and vascularity (effect size 0.560) significantly decreased ($p < 0.001$, respectively). However, the pairwise comparisons showed that the differences in the patients' scar mean height and pigmentation scores were only significant until the fourth (mean difference 1.59) and second treatment sessions (mean difference 2.83), respectively. In addition, there was no significant difference observed in the patients' scar mean vascularity scores between the baseline and second treatment sessions (mean difference 4.40); however, after the fourth treatment session, this score significantly and consistently improved until the eighth treatment session. The representative photographs are shown in Figure 3.

There were no significant differences observed in the subgroup analysis of the mean VSS scores between those patients who received ICS treatment and those who did not. Although the mean scar height initially decreased more in the ICS group than in the non-ICS group, the overall change did not significantly differ between the ICS and non-ICS group (66.1% and 77.0%, respectively). Moreover, the overall change in the other quantitative parameters did not differ significantly between the groups (Figure 4).

TABLE 1 Demographic and clinical characteristics of the study population

Characteristics	Patients with hypertrophic scar ($N = 19$)
Sex, *N* (%)	
Female	19 (100.0)
Age, median (IQR), years old	39 (30–43)
Fitzpatrick skin type, *N* (%)	
III	5 (26.3)
IV	14 (73.7)
Cancer type, *N* (%)	
Papillary carcinoma	18 (94.7)
Follicular carcinoma	1 (5.3)
Disease duration, median (IQR), days	80 (22–177)
Vancouver Scar Scale, median (IQR)	
Vascularity	2 (1–3)
Pigmentation	2 (1–2)
Pliability	2 (1–3)
Height	3 (1–3)
Total	9 (8–10)
Previous treatment, *N* (%)	
Intralesional corticosteroids	0 (0.0)
Cryotherapy	0 (0.0)
Silicone gel sheets	19 (100.0)
Laser	0 (0.0)

Abbreviation: IQR, interquartile range.

DISCUSSION

In this prospective study, we found that the 595 nm PDL effectively reduced the effects of HSs in patients with post-thyroidectomy. The HS characteristics of height, pigmentation, and vascularity were improved. We also evaluated and verified these factors using a three-dimensional skin imaging device (Antera 3D™), that quantitatively assessed various skin parameters.[23,24] Although patient satisfaction persistently increased throughout the eight treatment sessions, we suggested four to six session of 595 nm PDL treatment as an optimal treatment end point of thyroidectomy HSs based on the objective analysis and consideration for treatment effectiveness and cost.

Similar to a previous study,[21] we observed an overall statistically significant increase in the patients' VSS scores after eight treatment sessions with the 595 nm PDL; however, no statistically significant improvement was

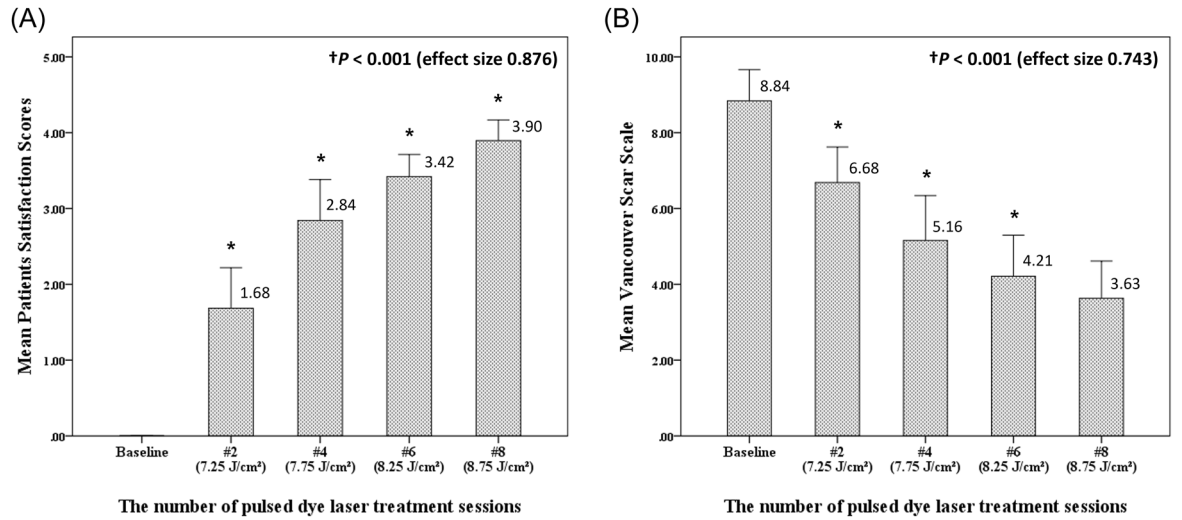

FIGURE 1 Changes in mean scores of the patient satisfaction questionnaire and Vancouver Scar Scale (VSS). The mean patient satisfaction scores significantly increase at all time intervals up to 3.90 (maximum score 4; A). The mean VSS scores significantly decrease from 8.84 to 3.63, but do not significantly decrease between the sixth and eighth treatment sessions with the 595 nm pulsed dye laser (PDL; B). †One-way repeated measure analysis of variance (ANOVA) *Pairwise comparisons using Bonferroni post-hoc tests.

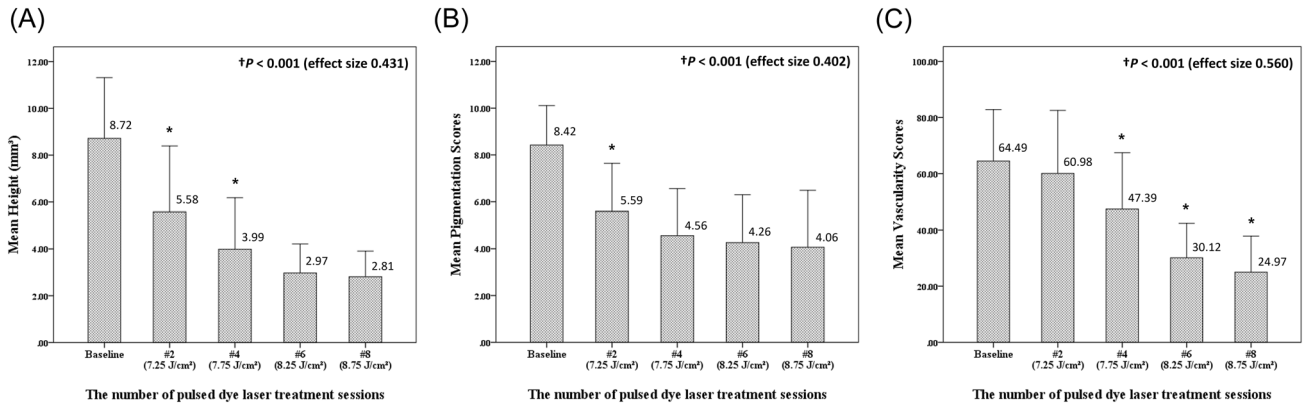

FIGURE 2 Quantitative analysis of the scar characteristics using Antera 3D™. The mean height (A), pigmentation (B), and vascularity (C) scores significantly decrease after 595 nm pulsed dye laser (PDL) treatment sessions. The differences in mean pigmentation and height scores are only significant until the second and fourth treatment sessions, respectively. Mean vascularity scores between the baseline and second treatment session are not significantly different, but after the fourth treatment session, this score significantly and consistently improves until the end of the PDL treatment sessions. †One-way repeated measure analysis of variance (ANOVA). *Pairwise comparisons using Bonferroni post-hoc tests.

observed in the last treatment session. Our results showed an improvement effect of the pigmentation and height of the patients' HS only from baseline to the second and fourth treatment sessions, respectively. However, the vascularity of the patients' HS showed a sustained improvement over the course of all treatment sessions, even though the initial response time for vascularity was later than that for the patients' scar height and pigmentation. This may be explained by the mechanisms of PDL action. Melanin pigment is a competitive chromophore to hemoglobin at the wavelength of the PDL,[25] and the absorption of epidermal melanin is relatively more prominent than oxyhemoglobin at this wavelength especially in higher Fitzpatrick skin types,[26] such as that of our patients. Moreover, the patients with initially higher pliability score had undergone the ICS treatment, resulting in improvement of scar height. These might contribute to an initial clinical improvement of pigmentation and height rather than that of vascularity. In the later stage, PDL more selectively targets hemoglobin and coagulates the microvasculature in the capillary and reticular dermis, resulting in the destruction of pathologic neovascularization.[25,27] For these reasons, the beneficial effects of scar vascularity may be superior and more consistent than that of scar height or pigmentation. Taken together, although patient satisfactions subjectively and consistently increased through PDL treatments, (1) objective improvement of vascularity appeared after four session treatments, (2) that of height appeared

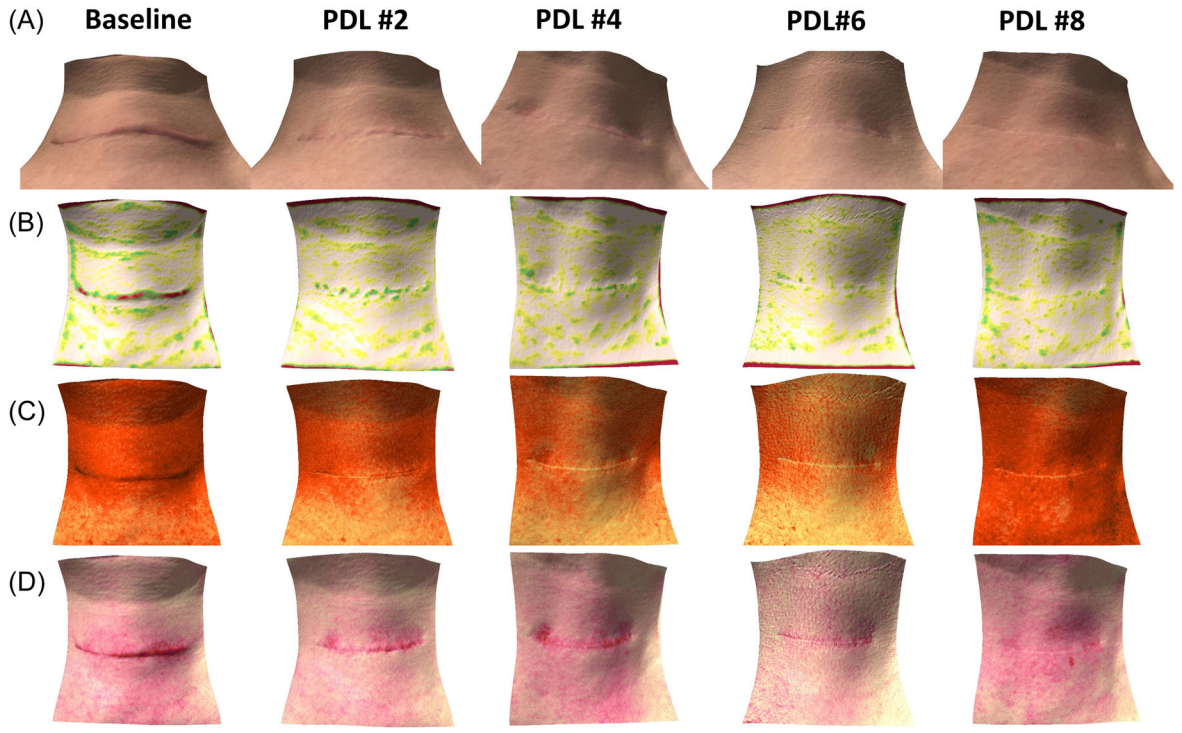

FIGURE 3 Representative photographs taken by Antera 3D™. The original three-dimensional skin texture (A), scar height (B), pigmentation (C), and vascularity (D) improves over the 595 nm pulsed dye laser (PDL) treatment sessions.

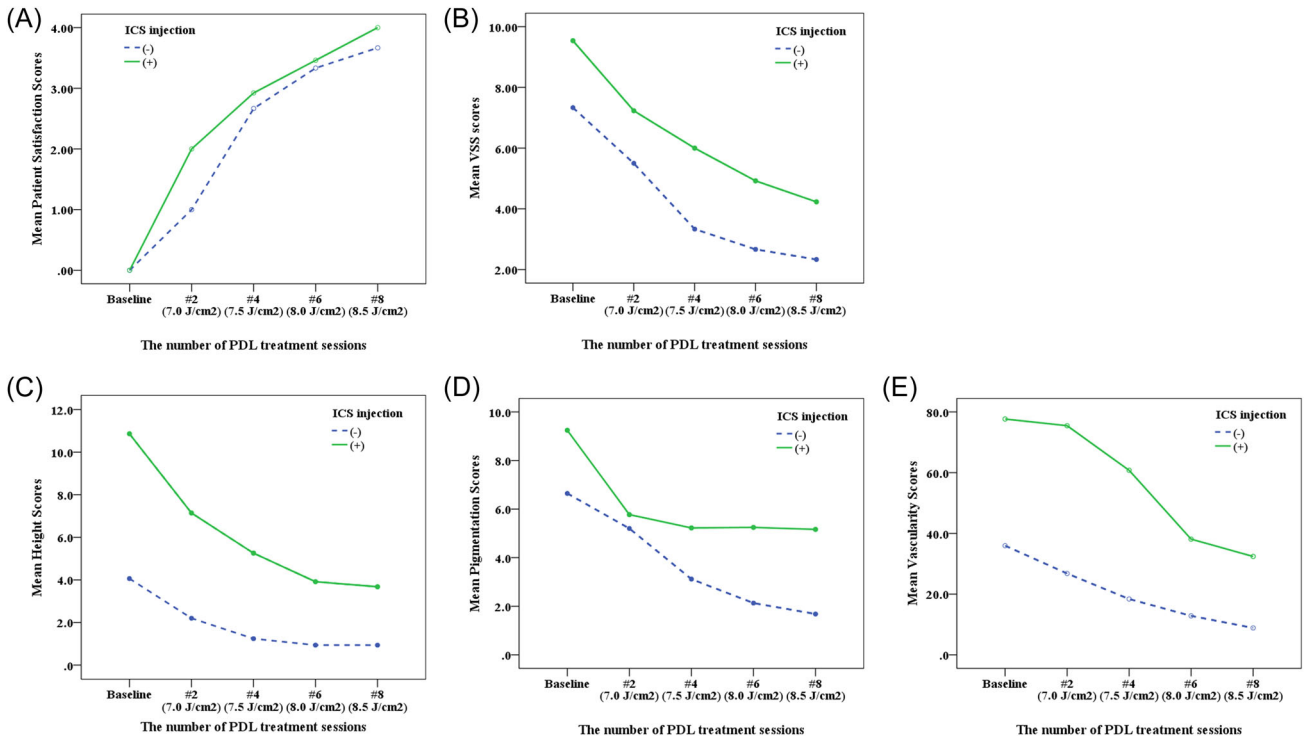

FIGURE 4 Comparison of changes in scar characteristics between patients with and without intralesional corticosteroid (ICS) treatments. No significantly different changes in the scores of the patient satisfaction questionnaire (A), Vancouver Scar Scale (VSS; B), scar height (C), pigmentation (D), and vascularity (E) are observed between those receiving and those not receiving ICS treatments.

until four-session treatments, and (3) that of VSS score appeared until six-session treatments. Based on our results, we suggest that four to six sessions of the 595 nm PDL may be a cost-effective treatment plan for patients with post-thyroidectomy HS.

The results of PDL treatment alone (without ICS treatment) showed a similar tendency toward the overall results. Although the patients who received ICS treatment had larger scar volumes at baseline and a higher reduction ratio of the patients' scar heights was initially observed when compared to those without ICS treatment, the volume reduction effect (at the following treatment session) was similar between two groups. Therefore, based on our results, treatment with the 595 nm PDL alone can reduce the elevated volume of post-thyroidectomy HS; however, combined treatment with ICS may be necessary in cases with severe scar elevation with VSS pliability score of more than one.

The limitations of this study are the small sample size and the absence of a control group. Therefore, we were unable to compare the difference in treatment response between patients who received treatment sessions with the 595 nm PDL and those without treatment. In addition, it is difficult to generalize our results to the other sex, races, or Fitzpatrick skin types because our study included only female patients with Fitzpatrick skin types III and IV.

In conclusion, this study showed that 595 nm PDL was effective in improving HSs in patients with post-thyroidectomy and we suggested a cost-effective treatment plan for PDL treatment. In addition, we showed that objective and quantitative assessments of HSs, as well as subjective and qualitative assessments such as VSS, were important in decision or plan of clinicians while treating the patients with post thyroidectomy HS with 595 nm PDL. However, further studies with a larger sample size and the use of treatment controls are required to confirm these results.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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